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AFFINITIES OF CERTAIN CRETACEOUS PLANT REMAINS COMMONLY REFERRED TO THE GENERA DAMMARA AND BRACHYPHYLLUM[1]

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INTRODUCTION

THIS paper is a preliminary contribution, designed to demonstrate the value of critical examinations of palæobotanical material by means of the microscope. The results obtained by such examinations of three kinds of Cretaceous fossil plant remains are described, *viz.*: cone scales commonly referred to the living genus Dammara, leafy branches commonly referred to the extinct Coniferous genus Brachyphyllum, whose exact botanical affinities have not heretofore been satisfactorily determined, and certain lignitic fragments found associated with the foregoing.

The first mentioned are shown to belong not to Dammara but to an extinct genus, closely related to it, to which the new generic name Protodammara is given. The second are shown to be Araucarinean in their affinities and probably to represent the branches of the tree which bore the cones from which the scales of Protodammara were derived. The third are shown to be referable to Araucarioxylon and probably to represent the wood of the tree which bore the leaves of Brachyphyllum and the cones of Protodammara.

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[1] Read before the Botanical Society of America, New Orleans meeting, January 4, 1906.

Contributions from the Phanerogamic Laboratories of Harvard University. — No. 4.

Contributions from the New York Botanical Garden.— No. 79.

DISCOVERIES WHICH SUGGESTED THE PREPARATION OF THIS PAPER

The discoveries which suggested the preparation of this paper were described in a previous paper read before the Botanical Society of America at the Philadelphia meeting, on December 30th, 1904.[1] During the autumn of that year an interesting section of Cretaceous deposits was found exposed in the Androvette clay pit, at Kreischerville, Staten Island, N. Y. At this locality the deposits consist of irregularly stratified sands and clays, in one part of which occurs a lens-shaped bed of closely packed vegetable *débris*, consisting of leaves, cone scales, twigs, amber, charred wood, and lignite. At that time special attention was given to the amber and the other remains were merely examined superficially and briefly mentioned. The suggestion was made by Dr. Jeffrey that critical examination of the lignitic fragments would probably produce interesting results, and this suggestion led to two joint visits to Kreischerville during the past year and the collection of a large amount of new material, in part from the original locality and the remainder from the nearby Drummond pit. Some of the results obtained from the examination of this material form the basis of this contribution.

OBJECT AND SCOPE OF THE INVESTIGATION

One of the great difficulties in connection with any attempt to determine satisfactorily the relationships of palæobotanical specimens is due to the fact that such specimens are nearly always more or less fragmentary, being represented only by dismembered parts or organs of plants, and seldom or never by a complete individual organism. Under such conditions it is not surprising that descriptions based upon superficial characters only have frequently resulted in erroneous generic determinations; different parts of the same species have often been described under two or more specific or generic names; or occasionally a single specific name was made to include several different fragments which were subsequently ascertained to belong to two or more distinct species.

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[1] Arthur Hollick. "The Occurrence and Origin of Amber in the Eastern United States." Published in *Amer. Nat.*, vol. 29, pp. 137–145, *pls. 1–3*, 1905.

The identification or determination of a genus solely from the shape or superficial markings of a cone or some of its detached scales or of a leaf or a leafy twig, can seldom be entirely conclusive or satisfactory; but it may be readily appreciated that if, in addition, the internal structure of such specimens can be made out by the use of the microscope, not only may the genera be thus determined beyond question, but many fragmentary scattered remains, presenting no superficial characters of any diagnostic value, might thus be identified and brought together into their true generic and specific relationships.

Superficial examination of the Kreischerville material showed that it contained a number of recognized species, descriptions of which were based upon well defined external characters, besides quantities of specimens which were not identifiable by ordinary means. This indicated a specially favorable field for investigation, of which advantage was taken, and the methods employed, together with some of the selected results obtained, are here described.

Description of the Gross Material

Botanical Characters of the Plant Remains.— A rough examination of the gross material showed the presence of pteridophytes, angiosperms, and gymnosperms. The remains of the pteridophytes were exceedingly fragmentary and unsatisfactory. Those of the angiosperms consisted for the most part of dicotyledonous leaf impressions in the clay, usually accompanied by a thin film of carbonaceous matter, which generally disappeared on exposure to the air.

The remains of the gymnosperms proved to be more satisfactory, however, being represented not only by isolated coniferous leaves which retained more or less of the substance of the plant, but also by leafy twigs and branches, cones and cone scales, and fragments and logs of lignite, some of which contained amber in their interstices. Special attention was therefore given to these remains amongst which specimens of the following genera and species were separated out and identified.

List of the Coniferous Remains

1. Cone scales, allied to Dammara and similar to very small specimens of *D. microlepis* Heer. These are described in this paper on p. 199 under the new generic name Protodammara.
2. Cone scales and leaves of *Pinus* sp. The scales are relatively small. Several of the leaf specimens showed three in a bundle, enclosed in a sheath.
3. Leafy twigs of *Sequoia reichenbachi* (Gein.) Heer, *S. heterophylla* Vel., *Juniperus hypnoides* Heer, *Widdringtonites reichii* (Etts.) Heer, *Frenelopsis gracilis* Newb., and *Brachyphyllum macrocarpum* Newb.
4. Lignite and other fragmentary coniferous remains which could not be generically determined from their external characters.
5. Amber, occasionally in the interstices of the lignites, but for the most part in the form of small drops or "tears" and irregular fragments.

METHODS EMPLOYED IN THE CRITICAL EXAMINATION OF THE MATERIAL

Maceration and Separation of the Gross Material.— In the examination of the finer vegetable *dêbris* previously described the following method was employed. Caustic soda or potash in 1 to 3% solution was used with considerable success. After this treatment the fragments of plants were somewhat swollen and separated readily from one another and from the argillaceous matrix. The loosened clay was washed away on a wire gauze tray of not too fine meshwork and the lignitic or carbonaceous fragments were left in a clean and recognizable condition. The fragments in most cases were rather small, especially those of greatest interest, so that the most convenient method of recognition was by means of a dissecting microscope of very low magnification. A great many different kinds of coniferous remains were thus separated out and identified from their external appearance, as well as many charred specimens of dicotyledonous woods. Of these in general no account will be given at the present time, for attention was restricted to the cone scales similar to those referred by Heer to the genus Dammara, leafy branches belonging to the Brongniartian genus Brachyphyllum, and certain Araucarineous lignites. The chosen material was often in a very good state of preservation especially when charred, or partially charred.

Sectioning and Microscopic Examination of Specimens.— In the case of lignitic or charred vegetable remains it is necessary for successful study to obtain very thin sections, on account of the dark color and opacity of the fossilized tissues. By the use of hydrofluoric acid for removing mineral matter and by embedding in thickened celloidin, it was found possible to make sections often of large area, as thin as 5 micra which proved admirable for photomicrographic purposes. These sections were cleared at once in benzole without previous staining, since the natural dark color of the lignites was sufficiently pronounced to differentiate the structures, even in very thin sections. In some cases it was found necessary to reduce the natural dark hue of the preparations and chlorine water was useful for this purpose. The sections were mounted in balsam on plate-glass slides and after previous drying were subjected to pressure and high temperature in the warm oven for the purpose of making them perfectly flat. All the photomicrographs in the present article were made by means of Zeiss lenses, except those showing surface features. The latter were executed with the admirable Heliar lenses of the Spencer Lens Co. Electric light was employed in all cases as the illuminant.

Descriptions of Specimens

Cone Scales Commonly Referred to Dammara. — Fossil cone scales similar to ours were described and figured for the first time by Professor Edward Hitchcock,[1] in his account of the organic remains found at Gay Head, Martha's Vineyard. They were not named by him, but his figures and description leave little to be desired. He says: "Figs. 4, and 5, represent different individuals of another variety of vegetable remains. . . . These are not mere impressions; but a scale of carbonaceous matter, mixed with amber, marks the spot where the vegetable was imprisoned. . . . It seems to me very obvious that these remains must be the seed vessels of some coniferous plants."

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[1] *Final Rept. Geol. Mass.*, vol. 2, p. 430, *pl. 19*, *figs. 4*, *5*, 1841.

It was not until many years after Hitchcock's description was published that any further discovery of similar remains was made, or at least recorded, and to Professor Oswald Heer belongs the credit of first recognizing their affinities with the living Coniferous genus Dammara, in his description of specimens identical with those from Gay Head, under the name *D. borealis*,[1] from the Cretaceous of Greenland, in his discussion of which he says (p. 55): "Es haben diese Schuppen so grosse Aehnlichkeit mit derjenigen von Dammara (Agathis), dass wir sie derselben Gattung zutheilen dürfen." For purposes of comparison a figure of this species, representing a specimen collected at Gay Head, is shown on Plate 1, Fig. 1.

Two other so called species were also described and figured by the same author, *viz.*: *D. microlepis*[2] and *D. macrosperma*.[3] A specimen of the former, collected at the Gay Head locality, is shown on Plate 1, Fig. 2, which, by comparison, may be seen to differ from *D. borealis* merely in size. *D. macrosperma* has not been recognized in any collection of material except that from Greenland, and it is doubtful if it should be regarded as specifically distinct from the other two. In other words all three of these so called species might very well be included under *D. borealis*.

Heer was evidently in considerable doubt in regard to the identity of some of his specimens and also with regard to their botanical relationships. In his discussion of *D. microlepis* for example he says (p. 55, *loc. cit.*): "Hat einige Aehnlichkeit mit den Blüthenknospen des Eucalyptus Geinitzi," and a comparison with the figures of the objects which he refers to the fruit of that species[4] shows them to be so closely similar in appearance to his Dammara scales as to be practically indistinguishable from them.

Krasser, Beyer, and Velenovsky subsequently described and figured similar remains from the Cretaceous of Europe, with varying opinions as to their probable botanical affinities. The last author first referred them to *Eucalyptus geinitzi* Heer,[1] with the leaves of which species they were found closely associated, but later he called what are evidently identical remains *Dammara borealis* Heer.[2]

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[1] *Fl. Foss. Arct.*, vol. 6, pt. 2, p. 54, *pl. 37, fig. 5*, 1882.

[2] *Ibid.*, p. 55, *pl. 40, fig. 5*.

[3] *Ibid.*, vol. 7, p. 17, *pl. 53, fig. 11*, 1883.

[4] *Ibid.*, vol. 6, pt. 2, p. 93, *pl. 45, figs. 4–9*, 1882.

In 1889, Mr. David White visited Gay Head, and in the following year, in a paper "On Cretaceous Plants from Martha's Vineyard"[3] he described and figured specimens collected there, referring to them as follows (pp. 98, 99): "Next to the preceding species, the most numerous of the plants from Gay Head is *Eucalyptus Geinitzi* Hr., fig. 8–11, two of whose fruits, 'resembling unopened flowers of syngenesian plants,' were figured as 'scales of vegetable remains' in Hitchcock's Final Report. This species, first described from the Liriodendron beds (Middle Cretaceous) of Greenland, is abundant in and most characteristic of the Middle Cretaceous of Bohemia, and is also present in the same stage (Cenomanian) in Moravia. The specimen, fig. 11, is included here on account of its coincidence with one figured by Velenovsky (Foss. Flor. böhm. Kreide., iv, pl. xxv, fig. 7), which he supposed represented a flower of this species. It may belong to a conifer.

"The remains of the nuts show longitudinal furrows (white in the figures) filled with a resin which is 'indistinguishable by ordinary tests from Amber,' and which was observed and pronounced amber by Hitchcock in 1841. These doubtless are the remains of gum or oil vessels, such as exist in the nuts of recent Eucalypts; and the granules of 'amber' can hardly be else than Eucalyptus gum.

"The explanation is at once suggested that the fragments of amber observed by various writers, during the last hundred years, about Gay Head, and in the New Jersey Cretaceous, where also Eucalypts are found, are the product of the contemporaneous 'gum-trees,' rather than of some conifer. None of this American amber has, I believe, been tested for succinic acid, or to show its relation to true amber."

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[1] *Foss. Fl. Böhm. Kreideform.*, pt. 4, p. 1 [62], *pl. 1* [*24*], *figs. 1, 2; pl. 2* [*25*], *figs. 6–11; pl. 4* [*27*], *fig. 13 in part*, 1885.

[2] *Kvet. Cesk. Cenomanu*, p. 7, *pl. 1*, *figs. 28, 29*, 1889.

[3] *Amer. Journ. Sci.*, vol. 39, p. 93–101, *pl. 2*, 1890.

At about this same time Dr. J. S. Newberry was engaged in the investigation of the Cretaceous flora of New Jersey, the results of which were later included in his "Flora of the Amboy Clays."[1] In this work he lists *Dammara borealis* Heer as a characteristic and abundant element of the flora, and says (pp. 46, 47): "In his Flora Fossilis Arctica (loc. cit.) Professor Heer describes and figures the scales of a conifer which very much resemble those of *Dammara australis,* and yet there are some reasons for doubting the accuracy of his reference. It may also be said that the fruit scales which he calls *Eucalyptus Geinitzi*....are without doubt generically the same.... the fruits figured by Heer under the name of Eucalyptus are plainly scales, and are parts of an imbricated cone. I say this with confidence, because it has happened that in the Amboy clays we have found numbers of them sometimes associated together, oftener scattered and showing both faces. A peculiarity of these scales is that they are striped longitudinally by clefts which are filled with an amber-like substance. This structure is plainly seen in those figured by Professor Heer on Pl. XLV. Similar scales are described in an article by Mr. David White on the fossil plants from Gay Head....

"The considerations which have led me to doubt whether these cone scales are those of Dammara are that we have found no Dammara-like leaves associated with them, whereas in New Jersey they occur in great numbers mingled with and sometimes apparently attached to the branchlets of an extremely delicate conifer much like Heer's *Juniperus macilenta*.... Almost no other plant except this conifer is found with the cone scales, and it is difficult to avoid the conclusion that they belong together. Another reason for doubting whether these are the scales of a Dammara is that in some of them traces of two seeds are apparently visible, while in Dammara there is but one seed under each scale."[2]

The discussion is further continued by Dr. Newberry under his description of *Juniperus macilenta,* on pp. 54, 55 (*loc. cit.*), as follows: "Thickly scattered among the twigs there are cone scales and cones . . . . The cone scales are evidently identical with those described by Heer under the name of *Dammara microlepis*. . . . and probably with those described by him as *Dammara borealis*." He says, however, that they cannot belong either to *Dammara* or to *Juniperus* and finally concludes with the hope "that in the future material will be obtained that will enable us to reconstruct this tree and determine with accuracy its botanical relations."

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[1] *Monogr. U. S. Geol. Surv.*, vol. 26, 1895.

[2] This observation by Dr. Newberry is particularly interesting in the light of what we now know in regard to the Kreischerville specimens, as may be appreciated by referring to our description of the seed scars on those scales, on p. 199.

Dr. Newberry again refers to the scales in connection with his discussion of *Eucalyptus ? angustifolia,* in the following words (*ibid.*, p. 111): "Professor Heer feels strengthened in his reference of leaves having this nervation to Eucalyptus by finding in company with them what he regards as the fruit of Eucalyptus; but in my judgment the examples he gives of this fruit. . . . are rather detached scales of the cone of some conifer, and probably generically identical with the cone scales which he has called *Dammara borealis*."

Some years ago the senior writer of this paper began an investigation of the Cretaceous flora of the Atlantic coastal plain, and in the material collected in New Jersey and on Staten Island, Long Island, Block Island, and Martha's Vineyard, numerous specimens of cone scales were found, some of them unquestionably identical with *Dammara borealis* or *D. microlepis* as defined by Heer, and others which apparently represented new species. Following are references to the specimens in question:—

"*Dammara borealis,* Heer ?" Tottenville, Staten Island. *Trans. N. Y. Acad. Sci.*, vol. 12, p. 31, *pl. 1, fig. 17,* 1892.

"*Dammara borealis,* Heer." Chappaquidick, Martha's Vineyard. *Bull. N. Y. Bot. Gard.*, vol. 2, p. 402, *pl. 41, fig. 6,* 1902.

"*Dammara microlepis* Heer (?)." Ball's Point, Block Island. *Ann. N. Y. Acad. Sci.*, vol. 11, p. 57, *pl. 3, figs. 9 a, b,* 1898. At the time when these two specimens were described they were only referred provisionally to this species, in the following words: "The ones under consideration are, however, smaller than any which have been previously figured and might perhaps be referred to a new species, but in view of the limited amount of material and its fragmentary condition, I have thought it best to refer the specimens provisionally to Heer's species." I am now satisfied that they belong to the new genus and species hereafter described and they are included, for comparison, on Plate 1, Figs. 12, 13.

"*Dammara Northportensis* sp. nov." Little Neck, Northport Harbor, Long Island. *Bull. N. Y. Bot. Gard.*, vol. 3, p. 405, *pl. 70, figs. 1, 2,* 1904. A figure of this species is reproduced on Plate 1, Fig. 4.

"*Dammara (?) Cliffwoodensis* n. sp." Cliffwood, N. J. *Trans. N. Y. Acad. Sci.*, vol. 16, p. 128, *pl. 11, figs. 5–8,* 1897. A figure of the type specimen of this species is reproduced on Plate 1, Fig. 3. This species may also be found described and figured by Mr. Edward W. Berry in his "Flora of the Matawan Formation (Crosswick's Clays)," [1] and again in a subsequent paper on "Additions to the Flora of the Matawan Formation"; [2] but the figures more nearly resemble *D. borealis* than they do the species to which they are referred, and the author himself remarks, in regard to the one last mentioned (p. 70): "The specimen is an unusually perfect one.... In outline and size it is very similar to the scale from Tottenville referred by Hollick to *Dammara borealis* Heer."

Finally may be mentioned the species described and figured by Dr. F. H. Knowlton, under the name *Dammara acicularis,* in his "Fossil Plants of the Judith River Beds," [3] which differs from all the other species in the possession of a well defined apical awn or spine, although in many of our individual specimens a similar feature, of smaller size, is present, and in others its former presence is clearly indicated.

If all the opinions expressed by the authors in the papers quoted, are analyzed it may be seen that a majority favor the idea that the scales are Coniferous and that their relationships are with *Dammara,* or with some other genus closely allied to it. Whether more than one species is represented in the various forms that have been described as such is a problem which yet remains to be solved and its solution will doubtless be attended with more or less difficulty, but the identification of the genus to which each form belongs should be a comparatively easy task, provided the material available for study is such that it can be sectioned and subjected to critical examination under the microscope. Thus far the only specimens which we have so examined are those from Kreischerville, but it is hoped that the investigation may be continued in the future so as to include specimens from other localities.

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[1] *Bull. N. Y. Bot. Gard.*, vol. 3, p. 61, *pl. 48, figs. 8–11,* 1903.

[2] *Bull. Torrey Bot. Club*, vol. 31, p. 69, *pl. 1, fig. 11,* 1904.

[3] *Bull. U. S. Geol. Surv.*, no. 257, p. 134, *pl. 15, figs. 2–5,* 1905.

Protodammara speciosa n. gen. et sp.

Plate 1, Figs. 5–13; Plate 2, Figs. 1–5

"*Dammara microlepis* Heer (?)." Hollick, *Ann. N. Y. Acad. Sci.*, vol. 11, p. 57, *pl.* 3, *figs.* 9 *a, b,* 1898.

Organisms consisting of kite-shaped cone scales, from 4 to 6 mm. long by 4 to 6 mm. broad above, abruptly narrowed from about the middle to the base, rounded, incurved, and apiculate above; resin ducts five or more, extending down the lower surface of the limb; seed scars three in number, crescentically arranged above the middle and approximately in the broadest part of the scale, with the central one higher up than the laterals.

Plate 1, Figs. 5–13, shows the scales natural size; Plate 2, Figs. 1 a, b, c, 2, shows four specimens with the upper surfaces exposed, magnified about ten diameters. Although they may be seen to resemble closely those of a small female cone of Dammara they are distinguished from the scales of that genus by the apical process and by the fact that they obviously bore three seeds instead of only one. It might indeed be inferred, from the presence of three apically attached ovules, that we have here to do with cone scales of one of the Sequoiineæ, rather than with one of the Araucarineæ, but the internal structure shows that they are truly Araucarian.

Plate 2, Fig. 3, represents a transverse section of the base of a scale, magnified about 40 times. A little below the middle point may be seen a single small fibrovascular bundle. At a higher plane of section this separates off a single upper bundle of inverted orientation and gives off a number of lateral bundles to the lower surface of the scale. The upper bundle supplies the seeds. In the higher part of the scale the inferior bundles are surrounded by a dense cordon of transfusion tissue. The arrangement of the bundles of the scale presents throughout a close resemblance to that found in Dammara.

Plate 2, Fig. 4, represents about half of a transverse section of a scale, magnified about 50 times. The funicular attachment of one of the lateral seeds may be seen on the upper surface of the scale.

Plate 2, Fig. 5, shows a longitudinal section through the apex of the scale, which at the same time is also nearly median, magnified about 40 times.

There can be no doubt that these scales are Araucarian and that while they resemble the genus Dammara they do not belong to it. We have therefore proposed for them the generic appellation Protodammara.

Formation and Locality: Cretaceous clays, Raritan Formation. Pl. 1, Figs. 5–11 and Pl. 2, Figs. 1 a, b, c, 2, Kreischerville, Staten Island, N. Y.; Pl. 1, Figs. 12, 13, Ball's Point, Block Island, R. I.

Leafy Branches Commonly Referred to Brachyphyllum.—This genus was based upon the external characters of certain leafy branches, of Jurassic age, and was described under the noncommittal heading "Conifère douteuse." The type of the genus is *B. mamillare* Brongt., which he described but did not figure.[1] The species was figured by subsequent authorities however, notably by Saporta,[2] one of whose illustrations (fig. 4, *loc. cit.*), is reproduced on Plate 1, Fig. 14. A number of other species have also been described under the genus and under the closely related or synonymous genera Echinostrobus, Arthrotaxites, Thuites, Palæocyparis, etc. By some authors these genera have been all included under Brachyphyllum and by others they have either been regarded as distinct or else they have been grouped in various combinations. Their true botanical relationships, however, were never satisfactorily determined, although they were generally considered as allied to the Sequoiineæ or the Cupressineæ and as related to Arthrotaxis, Thuja, or Glyptostrobus. The species

[1] *Prod. Hist. Veg. Foss.*, p. 109, 1828.

[2] *Plantes Jurassiques*, vol. 3, *pl. 34*, *figs. 3–7*, 1884.

described by the earlier authors were all from Jurassic horizons but subsequently species were described from the Cretaceous,[1] and it is with these that we are especially concerned.

The question of generic identity between the several allied forms does not, however, come within the scope of this paper. The only matter which is of immediate concern is the fact that we have found at Kreischerville the leafy branches of a Brachyphyllum and have been able to determine, for the first time, by means of its internal structure, the exact relationship which it bears to certain living Coniferæ. This species is the same so far as external characters are concerned, as that described by Newberry from the Amboy clays of New Jersey (*B. macrocarpum* Newb., *loc. cit.*), and it has also been found at Northport, Long Island, and at Cliffwood, N. J. A reproduction of Newberry's fig. 1 (*loc. cit.*) is shown on Plate 1, Fig. 15, and the Northport specimens on the same plate, Figs. 16, 17. These are all natural size.

Plate 3, Figs. 1 a, b, c, shows three fragments of branches from Kreischerville, magnified about 6 times, and Fig. 2, on the same plate, shows one magnified about 10 times.

Plate 3, Fig. 3, shows a piece of another branch magnified about the same as the latter, and illustrates particularly well the longitudinal converging striæ characteristic of the leaves of Brachyphyllum.

Plate 3, Fig. 4, represents a transverse section through a relatively old branch, magnified by 8, in which the woody cylinder is well developed. The pith has largely collapsed, although it consists in large part of sclerotic cells.

Plate 3, Fig. 5, shows a transverse section of a young branch, magnified by 15. Four leaves may be seen on the margins of the figure, and of these, those on the broad upper and lower surfaces of the branch overlap those on the margins, as they are cut through at a higher region. The leaves are attached to the surface of the stem by practically all of their ventral surface, with only a very narrow border left free, where in their upper portions they overlap their neighbors. The anatomical features cannot be made out in this section as the magnification is not sufficient.

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[1] *Echinostrobus squamosus* Vel., *Gymnosp. Böhm. Kreideform.*, p. 16, *pl. 6, figs. 3, 6–8*, 1885; *Thuites crassus* Lesq., *Cret. and Tert. Fl.*, p. 32, 1883; *Brachyphyllum macrocarpum* Newb., "Fl. Amboy Clays" (*Monogr. U. S. Geol. Surv.*, vol. 26), p. 51, footnote, *pl. 7, figs. 1, 2, 5, 7*, 1895.

Plate 4, Fig. 1, shows a transverse section through the woody cylinder of the younger branch shown on Plate 3, Fig. 5. By using a lens it may be seen that at this stage the cylinder consists of clearly separated bundles. On the right a single leaf-trace is passing off.

Plate 4, Fig. 2, reproduces a cross section of the basal portion of a leaf from the margin of the same young branch. It may be seen that there are several fibrovascular bundles present. These have originated from the single trace previously described. Of the Cupressineæ, Sequoiineæ, and Araucarineæ, the only Conifers with which Brachyphyllum has ever been placed, *the latter group alone have the branched leaf-trace.*

Plate 4, Fig. 3, shows a similarly branching leaf-trace from one of the broad leaves which clothe the upper and lower surfaces of the stem in the genus Brachyphyllum.

Plate 4, Fig. 4, shows a portion of the latter under a higher degree of magnification. The lower fibrovascular tissue is obviously dividing into three branches.

Plate 4, Fig. 5, is part of a branch of Brachyphyllum in transverse section. The light spaces are the sections of resin-canals. Although the material was passed through a number of solvents of resin, used in a hot condition, there is still some matter present in the lumina of the resin-passages. This appears to be of a mucilaginous nature *and is comparable to that found among living Conifers only in the genera Araucaria and Dammara.*

Plate 4, Fig. 6, shows a transverse section of a diseased branch of Brachyphyllum, in which there is one particularly large resin-cavity. The fossil mucilage, as we consider it to be, is present also in this instance. We have, in fact, found this substance to be always present in Brachyphyllum, except in charred branches, and those which had become very rotten in the process of fossilization. *The mucilaginous contents of the resin-canals afford another reason for associating Brachyphyllum with the Araucarineæ rather than with the Cupressineæ or the Sequoiineæ.*

The most important argument, however, in favor of the Araucarineous nature of Brachyphyllum is the structure of the wood and phloëm. Plate 5, Fig. 1, is a longitudinal radial section of the tracheids of the wood, highly magnified. *They show the flattened and alternating bordered pits, which are the diagnostic feature of Araucarioxylon Kraus.*

Plate 5, Fig. 2, makes the diagnosis beyond dispute, as *it shows the very striking Araucarineous character of the rays.* Plate 5, Fig. 3, represents a transverse section through the xylem and phloëm in a yearling branch. Plate 5, Fig. 4, shows two bundles in the young stem of Brachyphyllum. It may be seen that *the region of the phloëm is marked by the absence of the regularly alternating rows of hard bast-fibers, which are found without exception in the phloëm of all Cupressineous and Sequoiineous Conifers.*

Lignites Referable to Araucarioxylon.— Associated with the cone scales of Protodammara and with the leafy branches of Brachyphyllum are found numerous specimens of lignite, amongst which are two types of Araucarioxylon. The first of these is very similar to the wood of the living Dammara, and like Dammara it is characterized by the presence of resinous tracheids. The pith, when present, is seen to be large and composed mainly of tanniniferous cells as in that genus. When wounded the wood of this Araucarioxylon does not give rise to traumatic resin-canals.

The second type, so far as we have been able to observe, does not possess resinous tracheids. The pith, when present, is sclerified and of small size as in Brachyphyllum. The wood, when injured, forms resin-canals of a traumatic character.

Plate 5, Fig. 5, shows a row of traumatic resin-canals in this species. Plate 5, Fig. 6, shows one of these resin-canals and the adjacent wood, highly magnified. The tracheids of the wood are seen to be free from resin. *This type of Araucarioxylon appears to be the wood of Brachyphyllum,* while the type first described appears to belong to Araucarian Conifers more nearly allied in structure to those now in existence.

CONCLUSIONS

The cone-scales referred by Heer to Dammara, at least in the case of those from Kreischerville, do not belong to that genus but to the hitherto unrecognized Araucarinean genus Protodammara.

The leafy shoots and branches from several eastern American Cretaceous beds referred by various authors to Brachyphyllum[1] are of Araucarian affinities, as shown by their structure and as indicated by their constant association with the cone scales of Protodammara.

A large part of the lignites associated with both the above are Araucarineous and probably represent in part the wood of the trees which bore the leafy branches of Brachyphyllum and the cones of Protodammara.

The latter genus was in all probability the last survivor of an ancient Araucarian line of descent, joined near its base with the primitive stocks of the Abietineous and Cupressineous series. Its anatomical characters show that it was forced to occupy less advantageous situations in Cretaceous times, and possibly in earlier periods as well. It may have grown on dry hills, while the better adapted related forms, which still survive in the modern genera Araucaria and Dammara, flourished in the richer lowlands, in company with other gymnosperms of higher type of development and with the angiosperms, which even then had begun to assume the predominant position which they occupy to-day.

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[1] We do not consider it by any means proved, that all the leafy branches of the type of Brachyphyllum are necessarily Araucarian. It appears not improbable that some of the shoots of this general type may belong to other families of the Conifers. This for example may well be the case with some Coniferous remains recently described by M. Zeiller, from the upper Lias of Madagascar and referred to Sequoiineous affinities. In this instance the cones were found attached to the branches and the author remarks that the superior portion of the cone scale terminates "en une pointe obtusement aigue", a somewhat suspicious feature of resemblance to our Protodammara.

PLATE 1

FIG. 1.— *Dammara borealis* Heer, natural size. Gay Head, Martha's Vineyard, Mass.

FIG. 2.— *Dammara microlepis* Heer, natural size. Gay Head, Martha's Vineyard, Mass.

FIG. 3.— *Dammara cliffwoodensis* Hollick, natural size. Cliffwood, N. J.

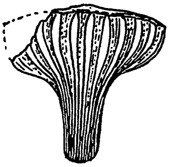
FIG. 4.— *Dammara northportensis* Hollick, natural size. Little Neck, Northport Harbor, Long Island, N. Y.

FIGS. 5–13.— *Protodammara speciosa* n. gen. et sp., natural size. Figs. 5–11, Kreischerville, Staten Island, N. Y.; Figs. 12, 13, Ball's Point, Block Island, R. I.

FIG. 14.— *Brachyphyllum mamillare* Brongt. (after Saporta), natural size.

FIG. 15.— *Brachyphyllum macrocarpum* Newb., natural size. South Amboy, N. J.

FIGS. 16, 17.— *Brachyphyllum macrocarpum* Newb., natural size. Little Neck, Northport Harbor, Long Island, N. Y.



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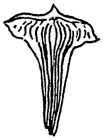

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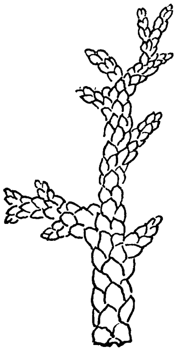

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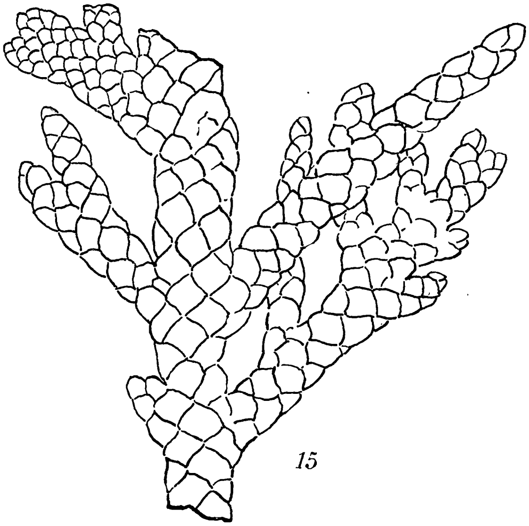

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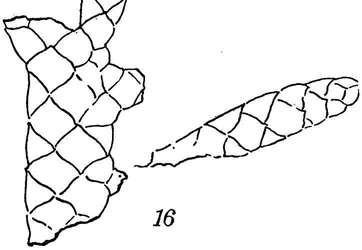

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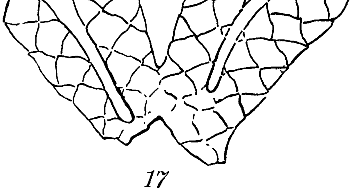

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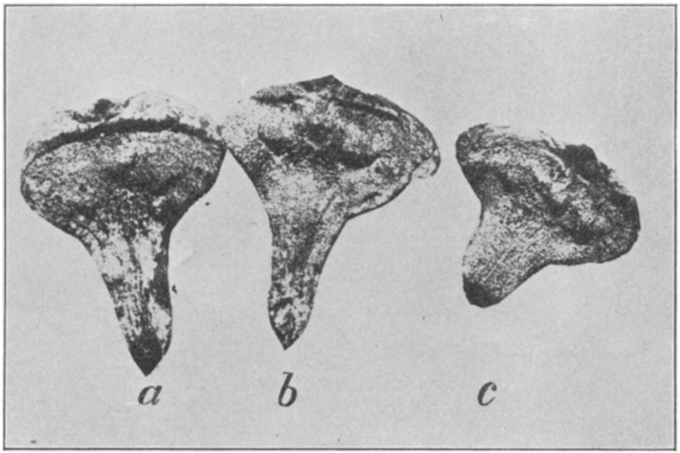
PLATE 2

Figs. 1–5.— *Protodammara speciosa* n. gen. et sp., enlarged. Kreischerville, Staten Island, N. Y.

Figs. 1 a, b, c, 2.— Upper surface of cone scales, × 10, or more.
Fig. 3.— Transverse section of the base of a scale, × about 40.
Fig. 4.— About half of a transverse section of a scale, × 50.
Fig. 5.— Longitudinal section through the apex of a scale, × 40.



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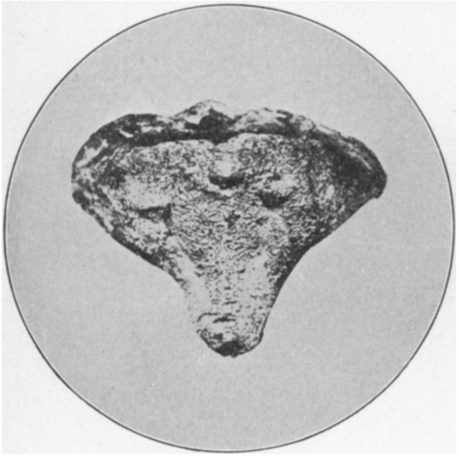

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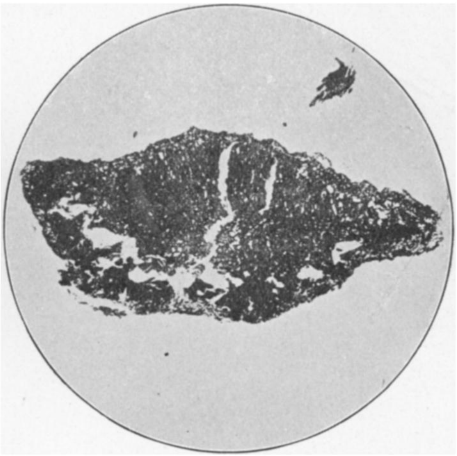

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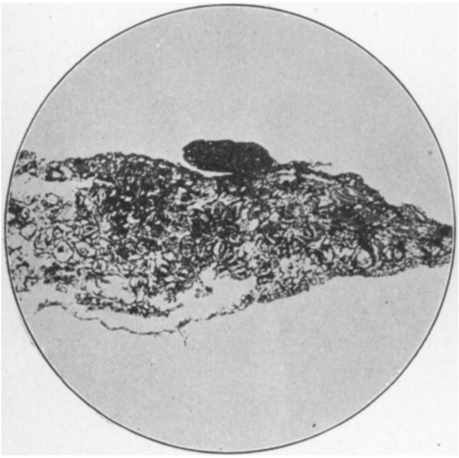

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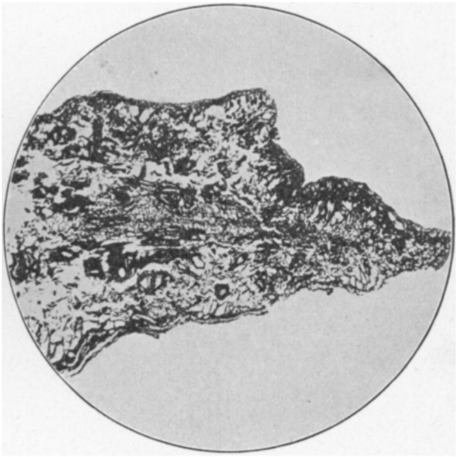

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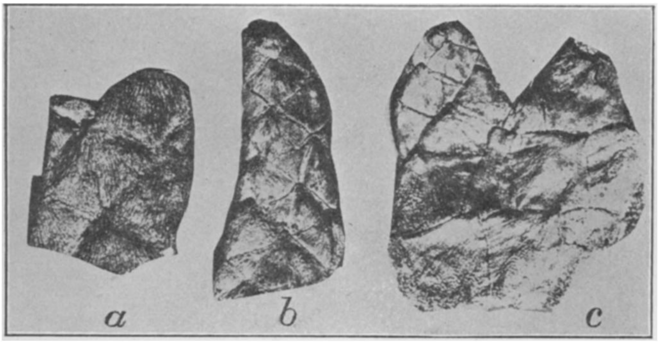
PLATE 3

Figs. 1–5.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y.

Figs. 1 a, b, c.— × about 6.
Figs. 2, 3.— × about 10.
Fig. 4.— Transverse section through a relatively old branch, × 8.
Fig. 5.— Transverse section through a young branch, × 15.



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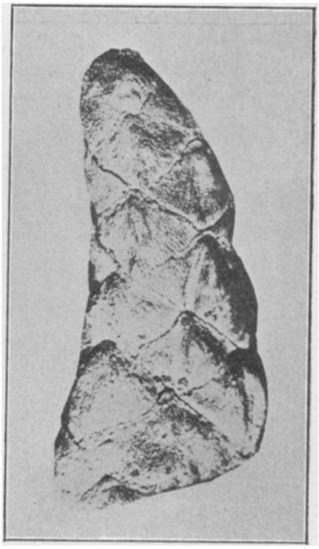

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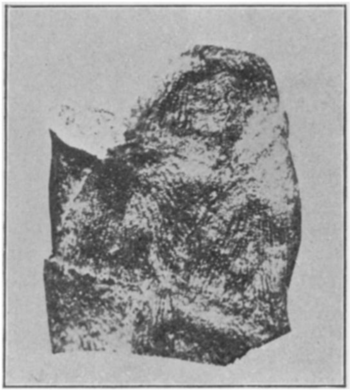

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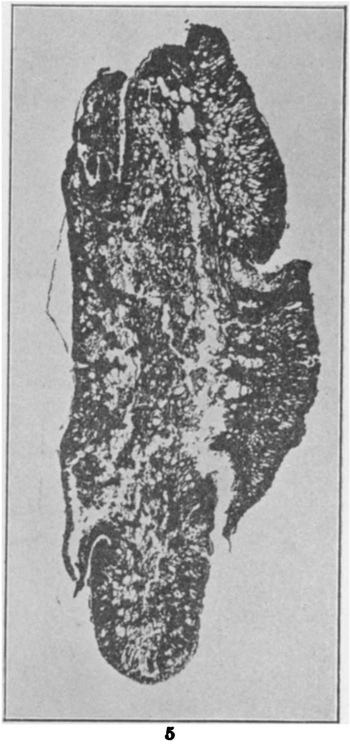

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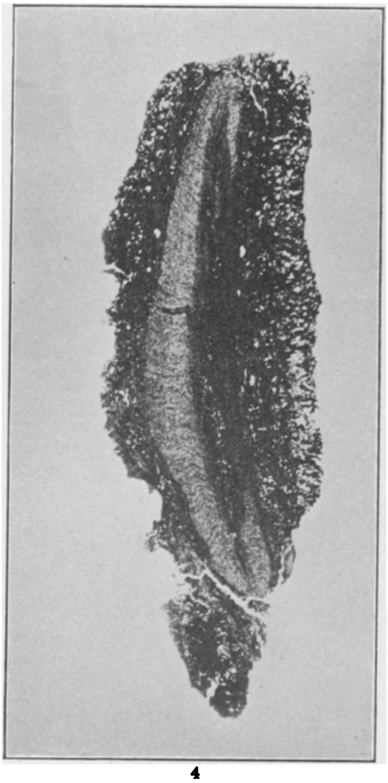

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PLATE 4

FIGS. 1–6.— *Brachyphyllum macrocarpum* Newb. enlarged. Kreischerville, Staten Island, N. Y.

Fig. 1.— Transverse section through the young woody cylinder of the branch shown on Plate 3, Fig. 5.

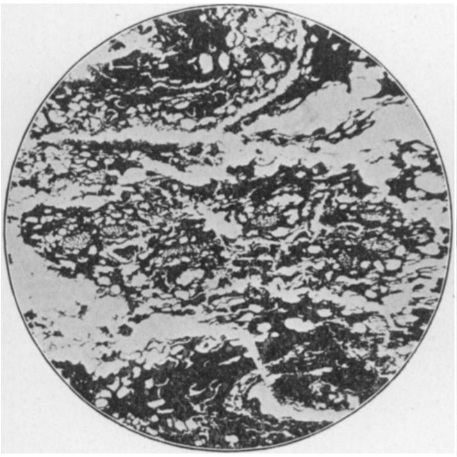
Fig. 2.— Cross section of the basal portion of a leaf from the margin of the same, × 50.

Fig. 3.— Same, showing a branching leaf trace, × 50.

Fig. 4.— More highly magnified, × 70.

Fig. 5.— Transverse section of a branch, showing resin-canals, × 30.

Fig. 6.— Transverse section of a diseased branch, showing a particularly large resin-canal, × 30.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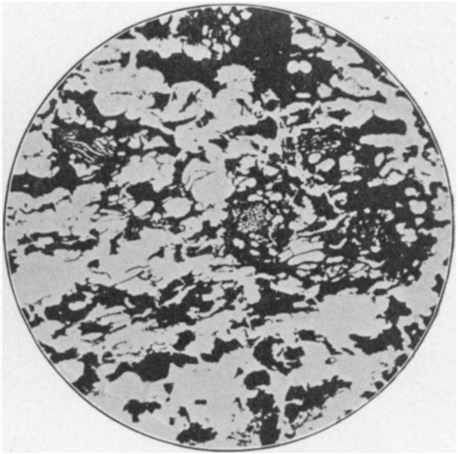
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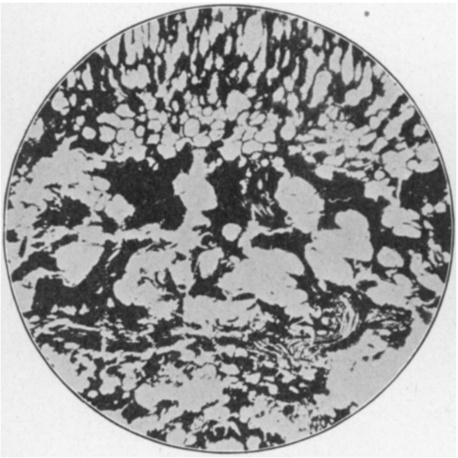
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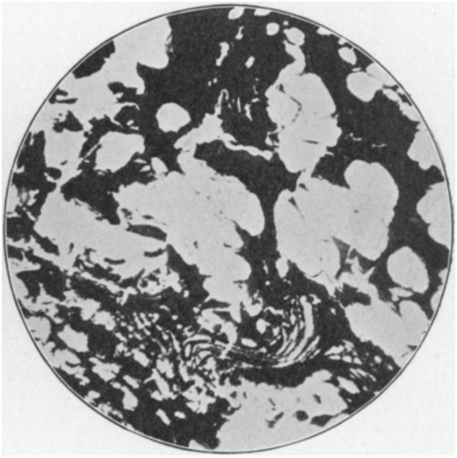
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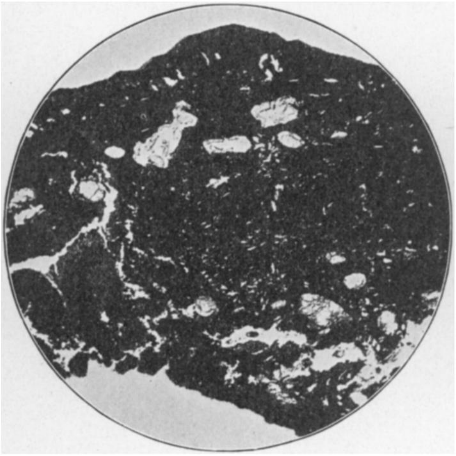
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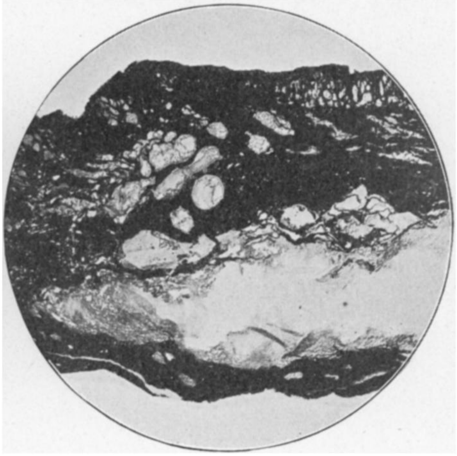
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PLATE 5

FIGS. 1–4.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y

Fig. 1.— Longitudinal radial section showing the radial pits of the tracheids, × 200.

Fig. 2.— Medullary ray showing the characteristic Araucarian lateral pits of the ray cells, × 200.

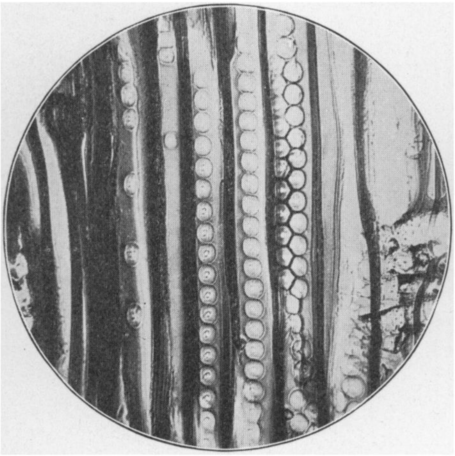
Fig. 3.— Transverse section of the xylem and phloëm in a yearling branch, × 200.

Fig. 4.— Transverse section of a young branch showing the xylem and phloëm, × 200.

FIGS. 5, 6.— *Araucarioxylon* sp., enlarged. Kreischerville, Staten Island, N. Y.

Fig. 5.— Transverse section of injured wood, × 50.

Fig. 6.— One of the traumatic resin canals of the same, × 150.



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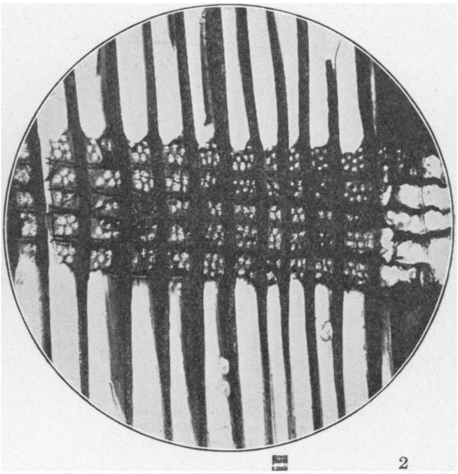

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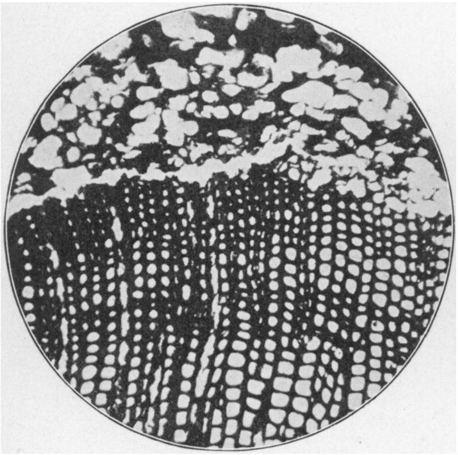

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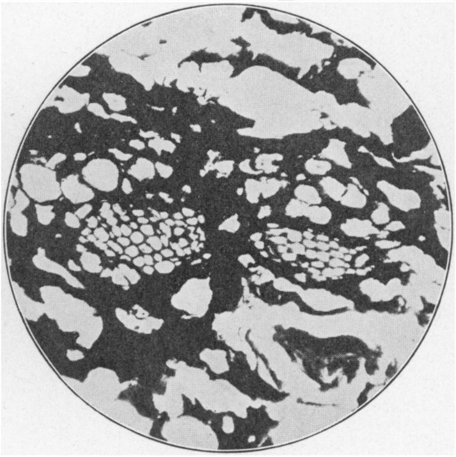

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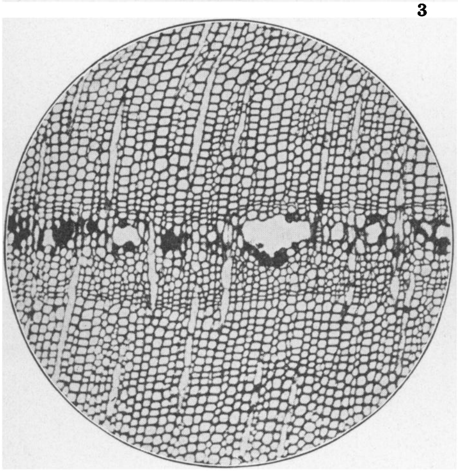

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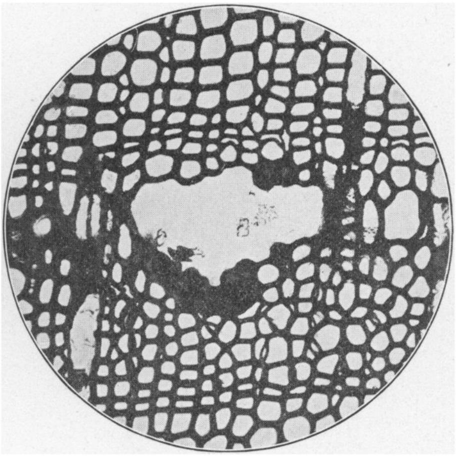

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